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Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires

# Earthquakes and Other Natural Hazards: GNSS for Disaster Management


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Sixth Meeting of the International Committee on Global Navigation Satellite Systems (ICG-6)
Mita Kaigisho
Tokyo, Japan

September 5, 2011

# Uses of GNSS to Fulfill Statutory Roles in USGS Hazards Mission Area

- USGS has the delegated federal responsibility to provide notifications and warnings for earthquakes, volcanic eruptions, and landslides.
- USGS seismic networks support NOAA’s tsunami warnings.
- USGS streamgages and storm surge monitors support NOAA’s flood and severe weather (including hurricane) warnings.
- USGS geomagnetic observatories support NOAA and AFWA geomagnetic storm forecasts.
- USGS geospatial information supports response operations for wildfire and many other disasters.





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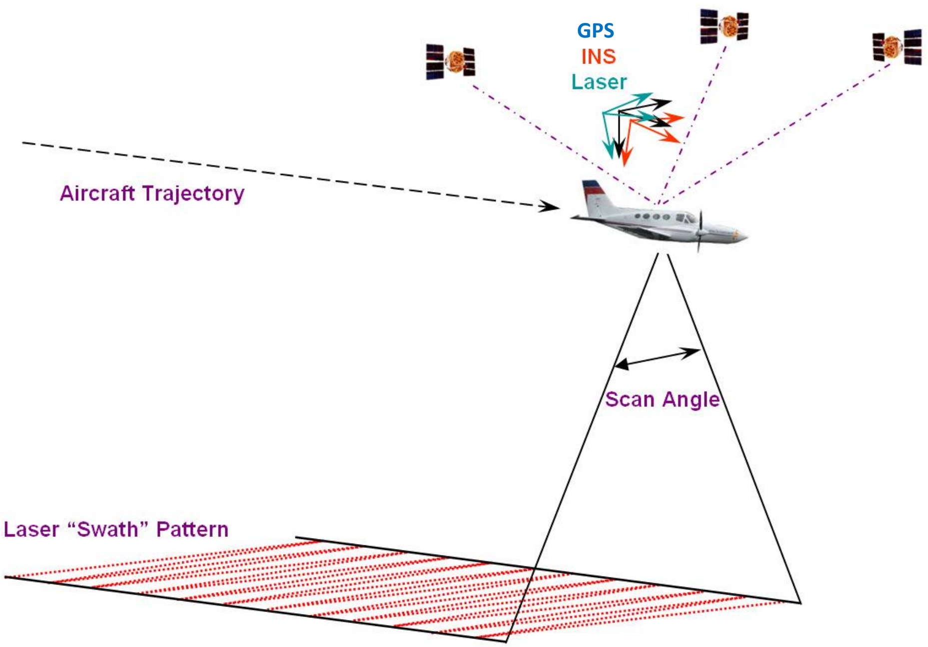
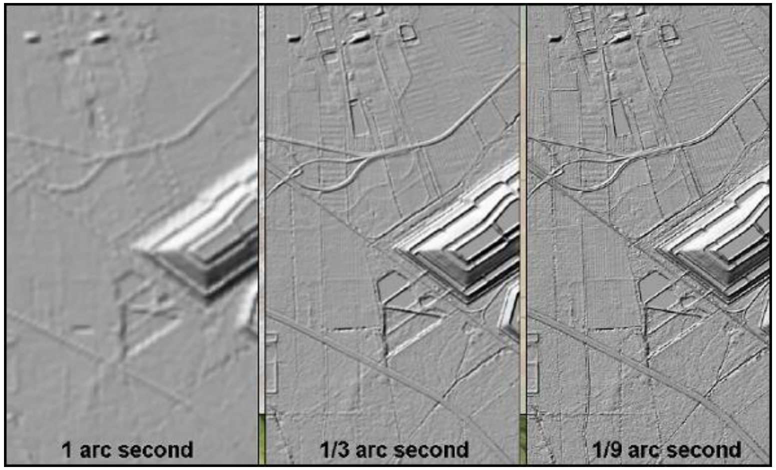
GPS is used to provide precise positions of airborne sensors so that highly accurate base geospatial data products such as high resolution terrain (elevation) data and orthorectified imagery can be produced efficiently.




Highly accurate terrain elevation data is replacing older, lower resolution data

Example of high resolution orthorectified imagery acquired in Partnership between USGS and other Fed, state, and local Govt agencies

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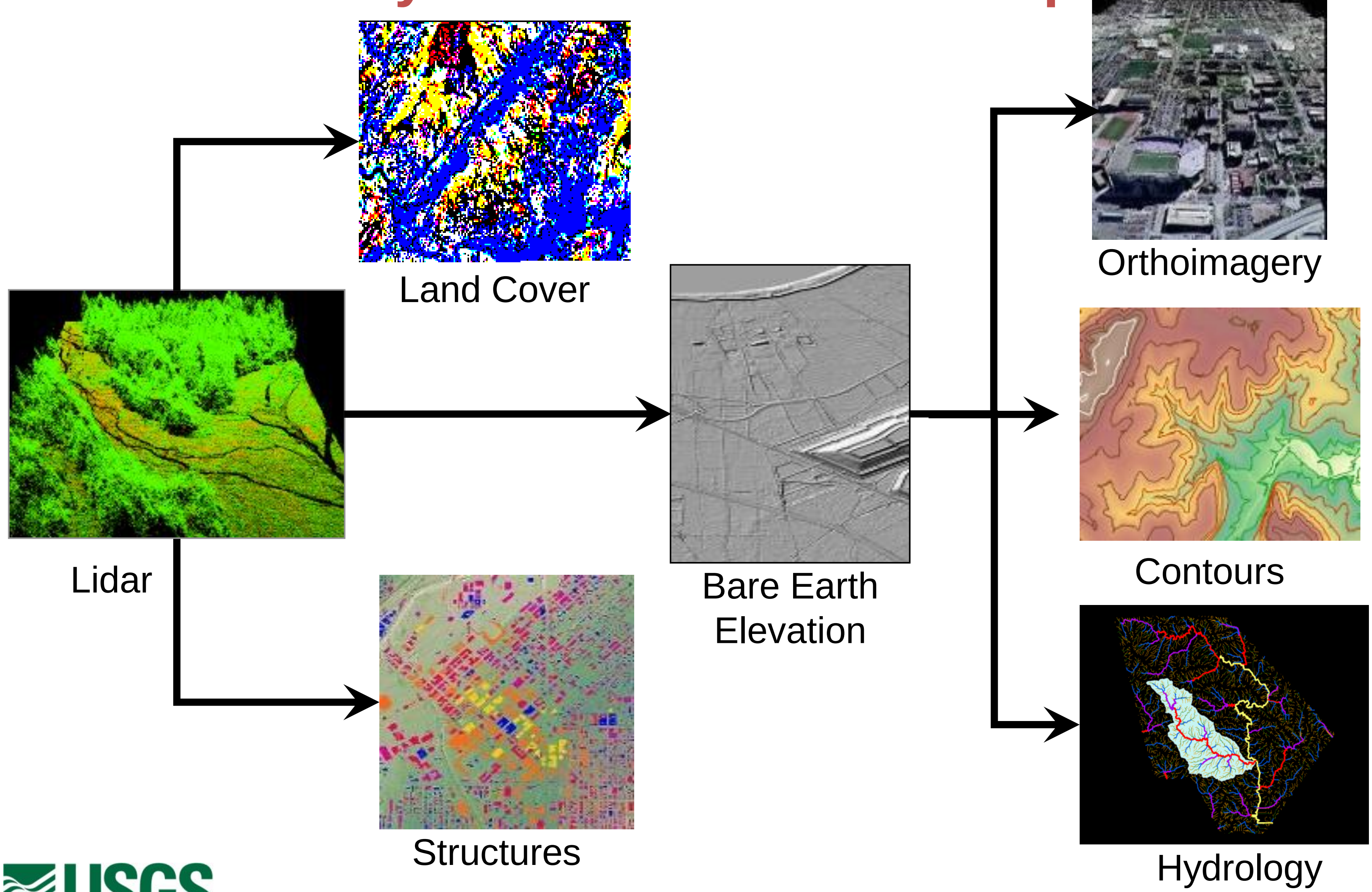
# Accurate LiDAR mapping is highly relevant to several data layers of The National Map

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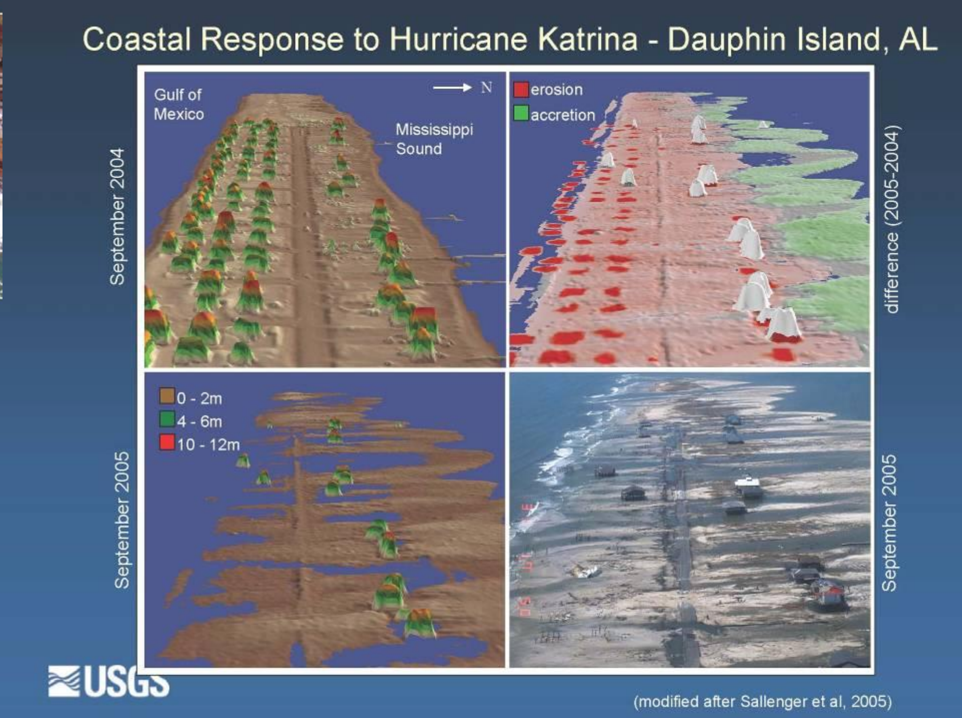
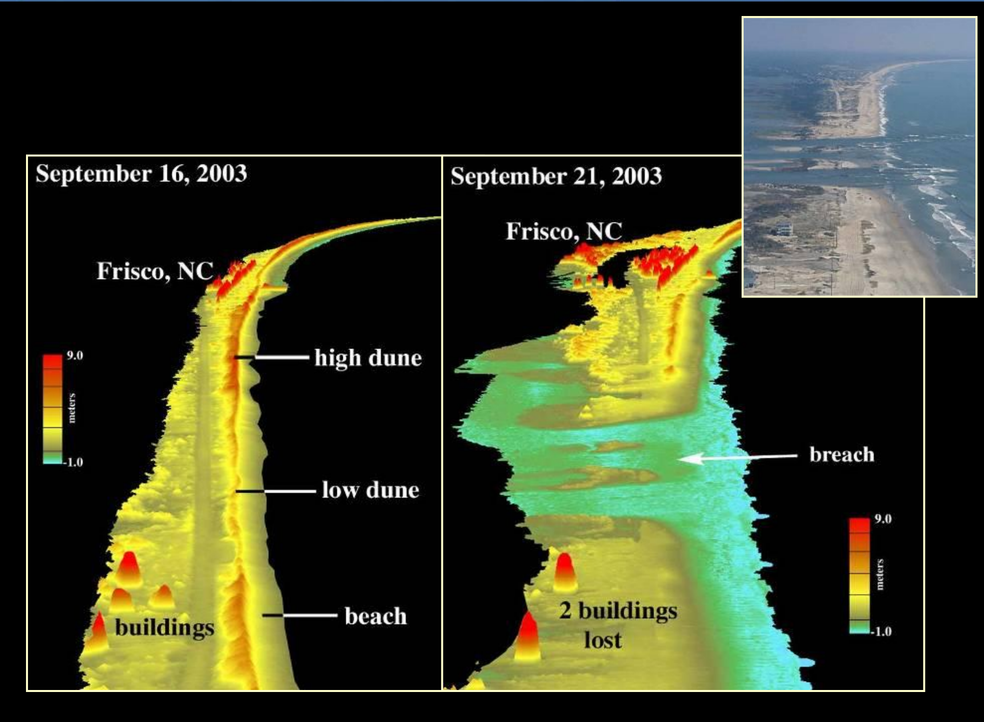
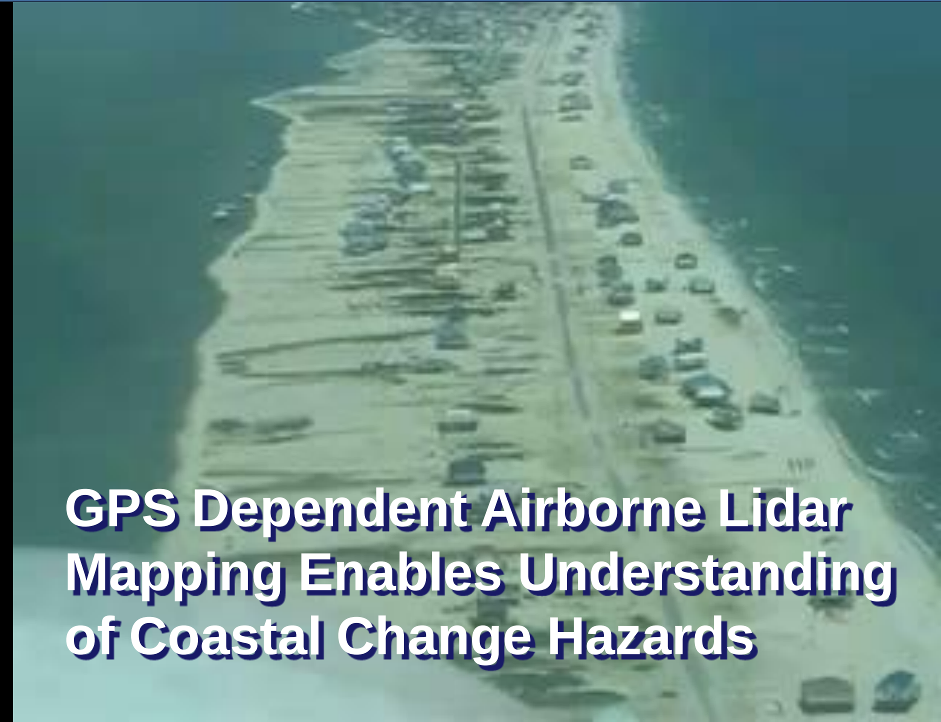
Coastal Change Hazards


Coastal Response to Hurricane Katrina - Dauphin Island, AL
Gulf of Mexico
N
Mississippi Sound
erosion
accretion
September 2004
difference (2005-2004)
0 - 2m
4 - 6m
10 - 12m
September 2005
September 2005
USGS
(modified after Sallenger et al, 2005)


September 16, 2003
Frisco, NC
high dune
low dune
beach
buildings
9.0
meters
-1.0
September 21, 2003
Frisco, NC
breach
2 buildings lost
9.0
meters
-1.0


GPS Dependent Airborne Lidar Mapping Enables Understanding of Coastal Change Hazards

# Aerial Images from GSI, Japan
# M9 Tohoku – need to re-establish a grid

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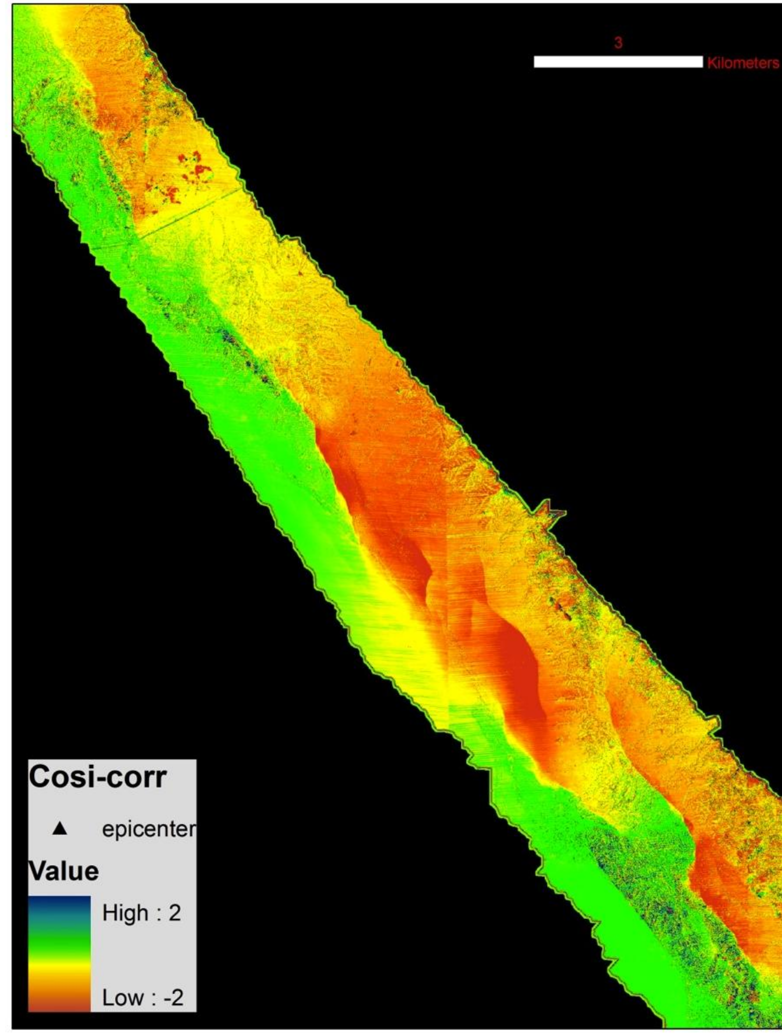
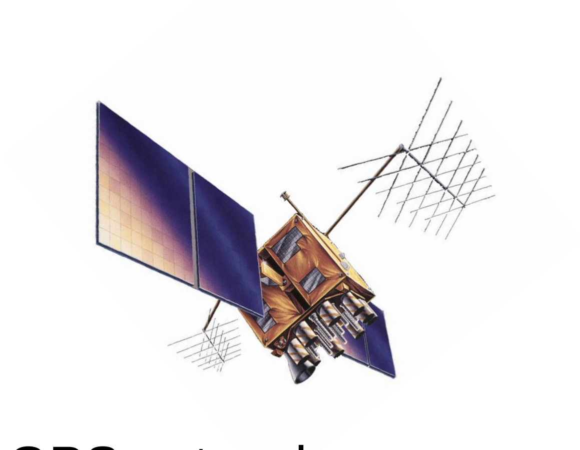



GPS enables ultra-high-precision geo-ref for fault mapping using repeat-pass imagery

- LiDAR
- 3D stereo


earthscope PROJECT

SCIGN
SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK



GPS network measures plate tectonic motions to an accuracy of better than 1 mm/yr

We can see whether the motion is ‘slow and steady,’ or perhaps more interestingly it may sometimes accelerate or decelerate

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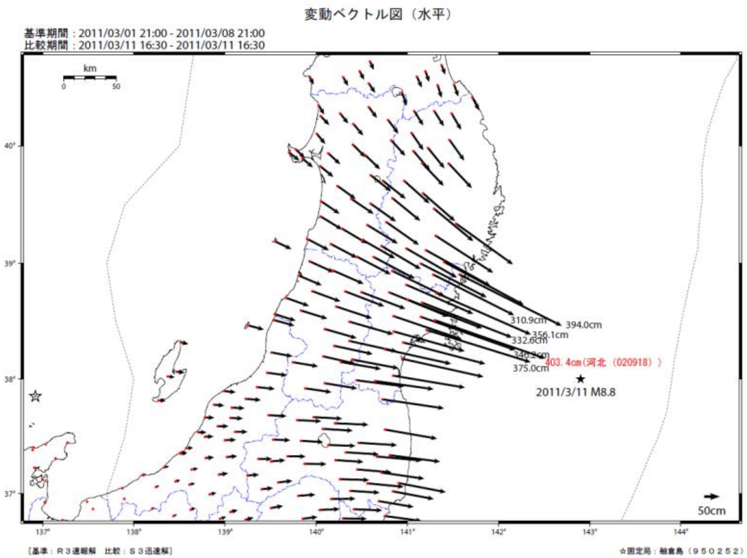
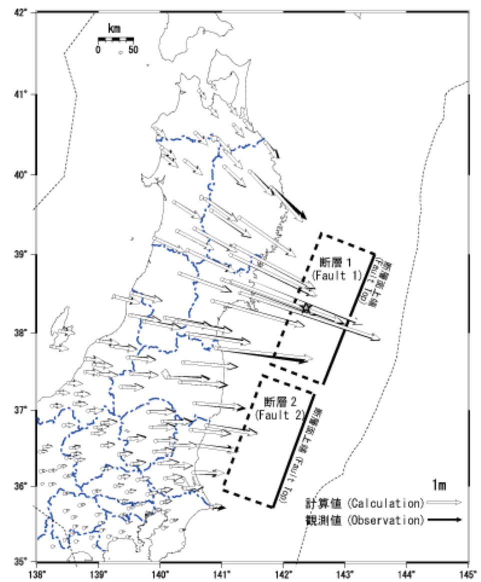
**During** 2011 Japan earthquake:

Initial GPS results from GSI showed 2.6 meters shift; later results gave maximum GPS offset of 4.034 m (that’s 13 feet)

Data were openly available and other groups quickly confirmed these results and made movies of the displacements to help visualize the information




星印は USGS の震央（142.369°，38.322°）
A Star indicates an epicenter released from USGS (142.369°, 38.322°)

矩形断層２枚での推定結果
Two rectangular faults with uniform slip are assumed.

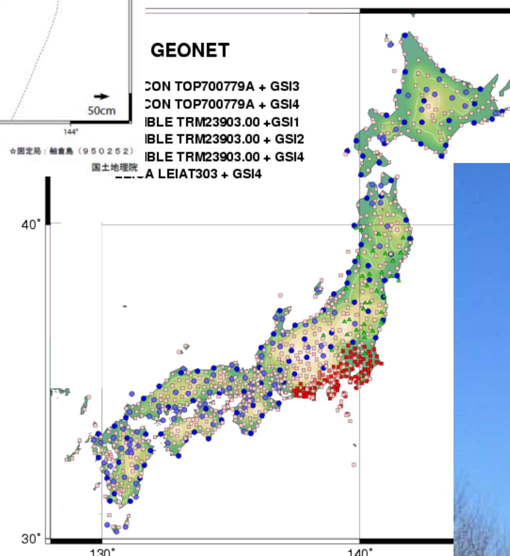
西側に傾き下がる逆断層．モーメントマグニチュードは北側（断層１）が 8.7，南側（断層２）が 8.2．２つ合わせて 8.8（暫定）．
West-dipping reverse fault. Total moment magnitude: Mw8.8. (Northern segment: Mw=8.7, Southern segment: Mw=8.2)

断層の長さは南北に約 200km の断層１と約 180km の断層２で合計約 380km．総延長はおよそ 400km．
Total major rupture length: ~400 km (Fault Length: Northern segment ~200 km / Southern segment ~180 km)

| | 緯度 Lat | 経度 Lon | 上端深さ Depth (Fault Top) km | 長さ Length km | 幅 Width km | 走向 Strike | 傾斜角 Dip | すべり角 Rake | すべり量 Slip m | Mw |
|---|---|---|---|---|---|---|---|---|---|---|
| 断層 1 | 39.00° | 143.49° | 10.0 | 199 | 85 | 202° | 18° | 97° | 27.7 | 8.7 |
| 断層 2 | 37.21° | 142.51° | 10.1 | 176 | 82 | 201° | 15° | 81° | 5.9 | 8.2 |

国土地理院資料
Geospatial Information Authority of Japan

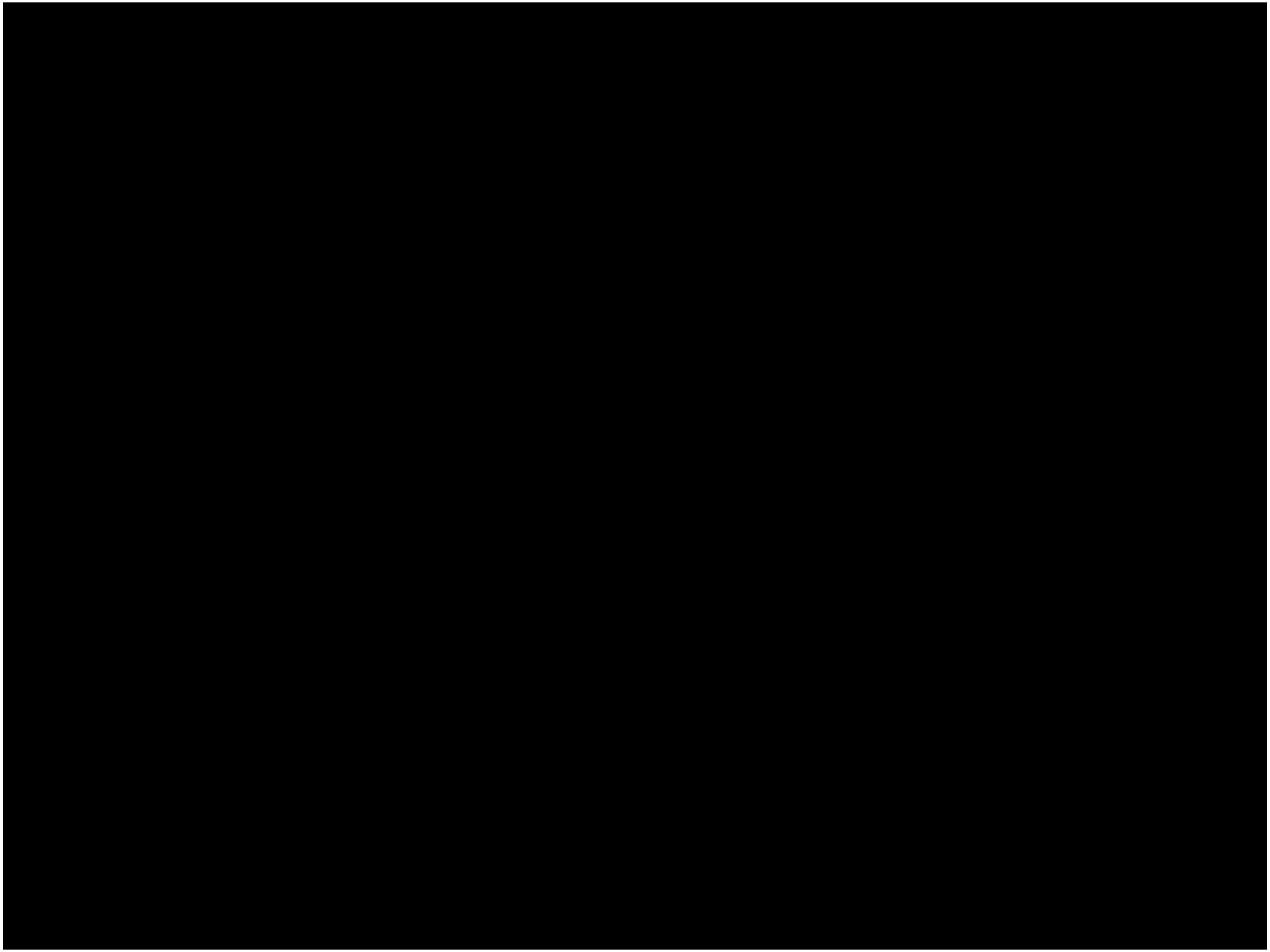
Since 1990, US advised Japan on construction of continuously-operating GPS stations (like ones we built in Southern California). They built a network of over 1000 GPS stations called GEONET.




**Post**-seismic:

re-adjustments will go on for years, GPS is the best way to examine it

# GNSS from GSI, Japan; M9 Tohoku



# GNSS uses for volcano monitoring

- Key component of volcano monitoring for flank movements and lava dome growth
- Integral part of US National Volcano Early Warning System plan for monitoring build-out
- Over 300 continuous GPS units are currently in use by USGS volcano observatories (nearly all of these are telemetered precise dual-frequency stations; many are Plate Boundary Observatory stations operated by UNAVCO with NSF funding)

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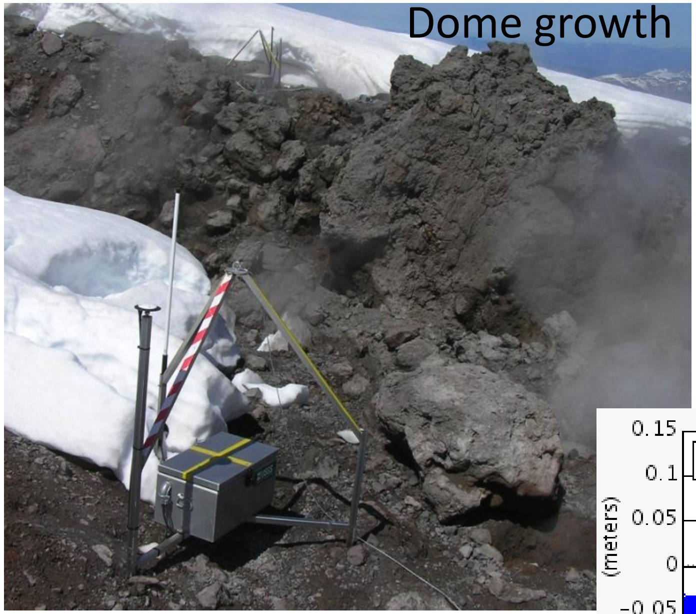
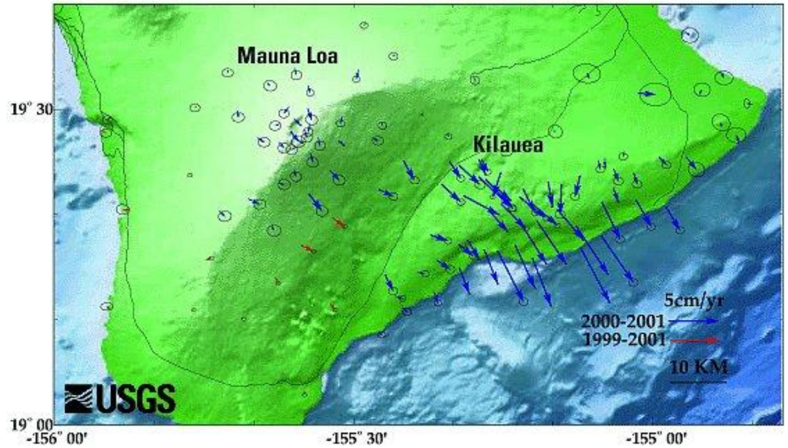
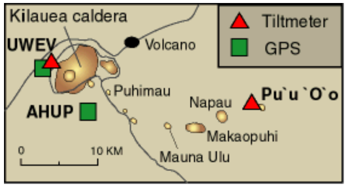
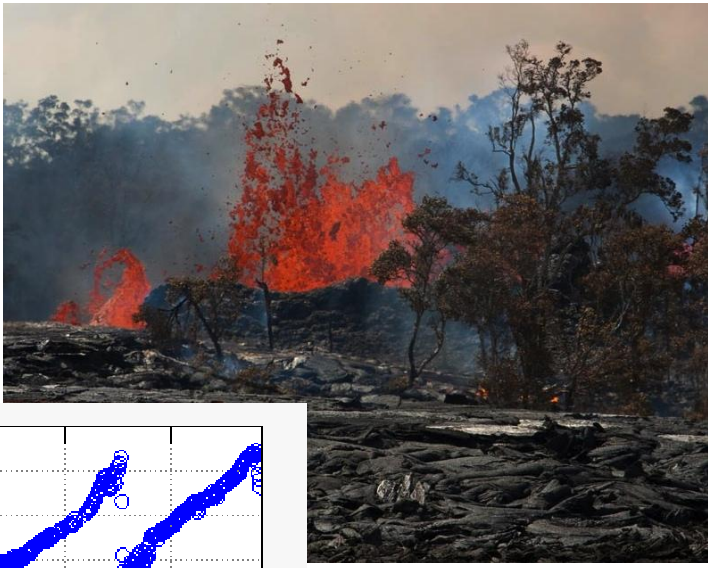
# USGS uses precise GPS for eruption monitoring of Kilauea, Mount Saint Helens and other volcanoes (Alaska, Long Valley, Yellowstone)

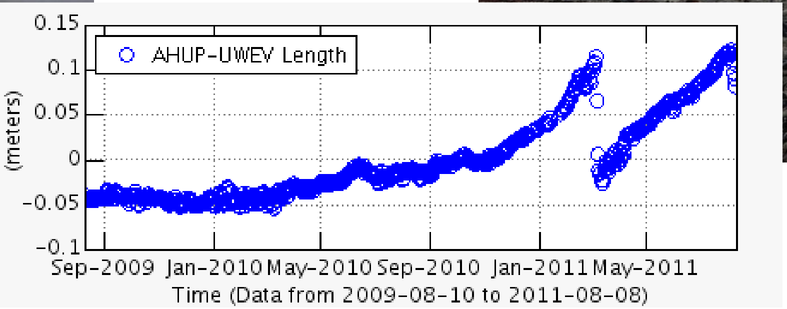




Motions of volcanoes' flanks can indicate the arrival of new magma; GPS is used to monitor changes in activity.





# GNSS for hazards management

- GNSS is an essential enabling technology for the mapping and precise monitoring needed to accomplish science missions in support of hazard warnings and other societal needs.
- In the aftermath of a significant disaster event, re-mapping and establishing a grid and geo-referenced incident data is essential in support of immediate response (e.g., Urban Search & Rescue) as well as for long-term recovery (e.g., organizing debris removal).

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